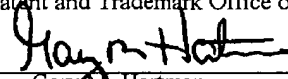


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U.S. Patent Application Serial No. **09/524,227**

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Attention: **EXAMINER Wesley D. Markham**
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THE FOLLOWING **71**-PAGE DOCUMENT IS A

RESPONSE AFTER FINAL

including:

- ☐ Response under 37 CFR §1.116
- ☐ Notice of Appeal
- ☒ Appeal Brief under 37 CFR §41.37
- ☐ Reply Brief under 37 CFR §41.41
- ☐ Request for Continued Examination (RCE) Transmittal
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PATENT

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Application No. : 09/524,227 Confirmation No. **6813**
Applicant : Irene T. Spitsberg
Filed: : March 13, 2000
TC/Art Unit: : 1762
Examiner : Wesley D. Markham

Docket No. : 13DV-13004
Customer No. : 30952

Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

APPEAL BRIEF UNDER 37 CFR §41.37

This is an appeal from the Examiner's final rejection made in an Office Action dated May 26, 2005 (Paper No. 20050524), of claims pending in the above-identified US patent application. Please charge the requisite fee and any other necessary charges to General Electric Company, Deposit Account No. 07-0865.

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REAL PARTY IN INTEREST

The real party in interest is the General Electric Company, the
assignee of record.

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RELATED APPEALS AND INTERFERENCES

There are no prior or pending appeals or interferences known to Appellant or Appellant's assignee or Appellant's representative that would directly affect or be directly affected by or have a bearing on this appeal regarding the above-identified patent application.

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STATUS OF CLAIMS

Claims 1-39 were originally presented in this application. Of these
claims:

Claims 21-39 have been canceled;

Claims 1-20 are pending in the application; and

Claims 1-20 are rejected.

Claims 1-20 are the subject of this appeal.

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STATUS OF AMENDMENTS

All amendments have been entered.

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SUMMARY OF CLAIMED SUBJECT MATTER

For the convenience of the Board, each independent claim under appeal is reproduced below, with the reference numeral of each element as denoted in the specification and drawings set forth in parentheses.

1. A method of improving the thermal fatigue life of a thermal barrier coating **(26)** by modifying the grain structure of a diffusion aluminide bond coat **(24)** that adheres the thermal barrier coating **(26)** to a surface of a superalloy component **(20)**, the method comprising the steps of:

depositing the aluminide bond coat **(24)** on the component **(20)** so as to be characterized by substantially columnar grains **(32)** that extend substantially through that portion of the aluminide bond coat **(24)** overlying the surface of the component **(20)**, the grains **(32)** having grain boundaries **(34)** exposed at the surface of the aluminide bond coat **(24)**, the surface of the aluminide bond coat **(24)** having surface irregularities as a result of grain boundary ridges defined by the grain boundaries **(34)** at the surface of the aluminide bond coat **(24)**; and then

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recrystallizing at least a surface region of the aluminide bond coat **(24)** during or prior to depositing the thermal barrier coating **(26)** on the surface of the aluminide bond coat **(24)**, wherein new grains **(42,48,50)** form at the surface of the aluminide bond coat **(24)** and a ceramic layer is deposited on the surface of the aluminide bond coat **(24)** to form the thermal barrier coating **(26)**;

wherein following the recrystallizing step the new grains **(42,48,50)** cause the surface of the aluminide bond coat **(24)** to be smoother and flatter as a result of eliminating at least some of the grain boundary ridges, whereby the ceramic layer is deposited on the smoother and flatter surface of the aluminide bond coat **(24)**.

11. A method of improving the thermal fatigue life of a thermal barrier coating **(26)** by modifying the grain structure of a diffusion aluminide bond coat **(24)** that adheres the thermal barrier coating **(26)** to a surface of a superalloy component **(20)**, the method comprising the steps of:

depositing the aluminide bond coat **(24)** on the component **(20)** by vapor phase aluminizing or by chemical vapor deposition, the aluminide bond coat **(24)** comprising an additive layer **(28)** on the

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surface of the component (20) and a diffusion zone (30) in a surface region (22) of the component (20), the additive layer (28) being characterized by columnar grains (32) that extend from the diffusion zone (30) to the surface of the aluminide bond coat (24), the grains having grain boundaries (34) exposed at the surface of the aluminide bond coat (24), the surface of the aluminide bond coat (24) having surface irregularities as a result of grain boundary ridges defined by the grain boundaries (34) at the surface of the aluminide bond coat (24);

peening the surface of the aluminide bond coat (24) at an intensity of at least 6A; and then

heat treating the aluminide bond coat (24) before or while depositing the thermal barrier coating (26) on the surface of the aluminide bond coat (24) so as to recrystallize at least a surface region of the aluminide bond coat (24), wherein new grains (42,48,50) form within the additive layer (28) at the surface of the aluminide bond coat (24), the new grains (42,48,50) causing the surface of the aluminide bond coat (24) to be smoother and flatter as a result of eliminating at least some of the grain boundary ridges and a ceramic layer is deposited on the smoother and flatter surface of the aluminide

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bond coat (24) to form the thermal barrier coating (26).

20. A method of improving the thermal fatigue life of a thermal barrier coating (26) by modifying the grain structure of a diffusion aluminide bond coat (24) that adheres the thermal barrier coating (26) to a surface of a superalloy component (20), the method comprising the steps of:

depositing the diffusion aluminide bond coat (24) on the component (20) by vapor phase aluminizing or by chemical vapor deposition, the diffusion aluminide bond coat (24) comprising an additive layer (28) on the surface of the component (20) and a diffusion zone (30) in a surface region (22) of the component (20), the additive layer (28) being characterized by columnar grains (32) that extend from the diffusion zone (30) to the surface of the diffusion aluminide bond coat (24), the grains having grain boundaries (34) exposed at the surface of the diffusion aluminide bond coat (24), the surface of the diffusion aluminide bond coat (24) having surface irregularities as a result of grain boundary ridges defined by the grain boundaries (34) at the surface of the diffusion aluminide bond coat (24);

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peening the diffusion aluminide bond coat (24) at an intensity of 6A to 12A;

heat treating the diffusion aluminide bond coat (24) at a temperature and for a duration sufficient to cause recrystallization of the entire additive layer (28) of the diffusion aluminide bond coat (24), wherein equiaxial grains (48) form within the additive layer (28), the equiaxed grains (48) causing the surface of the diffusion aluminide bond coat (24) to be smoother and flatter as a result of eliminating at least some of the grain boundary ridges; and then

depositing a ceramic layer on the surface of the diffusion aluminide bond coat (24) to form the thermal barrier coating (26) on the diffusion aluminide bond coat (24);

wherein the equiaxed grains (48) have a grain size of about fifteen to thirty micrometers.

As stated in the paragraph under "Field of the Invention" on page 1 of her specification, Appellant's invention is directed to a process of improving the spallation resistance of a ceramic thermal barrier coating (TBC 26) by modifying the grain structure of a diffusion aluminide bond coat (24) on which the coating (26) is deposited. An example of an application for the invention is

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a thermal barrier coating (26) of a type deposited on components of gas turbine engines, such as the blade (10) represented in Figure 1 of Appellant's application.

As explained in Appellant's specification starting on the first full paragraph of page 2, oxidation-resistant bond coats such as the diffusion aluminide bond coat (24) of this invention promote adhesion and extend the service life of a TBC (26). The diffusion aluminide bond coat (24) of interest to this invention differs from overlay bond coats (such as MCrAlX), for example, in the extent of the diffusion zone (30) that forms as a result of the extensive interdiffusion that occurs during the diffusion process by which the bond coat (24) is deposited on the component substrate (22). An intermetallic additive layer (28) overlies the diffusion zone (30). As explained in Appellant's specification starting at line 26 of page 2, exposure to high temperatures causes the bond coat (24) to form a tightly adherent alumina (Al_2O_3) layer or scale (36) on the additive layer (28) that adheres the TBC (26) to the bond coat (24).

In the paragraph bridging pages 2 and 3 of Appellant's specification, Appellant explains that the spallation of a TBC deposited on an overlay bond coat generally occurs within the TBC near the TBC-to-alumina interface. In contrast, TBC (26) deposited on a diffusion aluminide bond coat (24) typically spalls at the alumina scale-to-bond coat interface or within the alumina scale

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(36) itself.

The service life of a TBC deposited on an MCrAlY (overlay) bond coat has previously been shown to be improved by smoothing the bond coat surface by polishing or peening before depositing the TBC for reasons explained in Appellant's specification at lines 6-33 of page 3. However, because TBC spallation initiates by a different mechanism and at different locations within diffusion aluminide bond coats, the toughness of the alumina scale (36) and the alumina scale-bond coat interface have been deemed most important to the spallation resistance TBC (26) deposited on a diffusion aluminide bond coat (24), as explained in the paragraph bridging pages 3 and 4 of Appellant's specification. From this perspective, smoothing the diffusion aluminide bond coat (24) would be expected to reduce TBC life, since sufficient surface roughness of the bond coat (24) is desired to both promote adhesion of the alumina scale (36) to the bond coat (24) and inhibit crack propagation through the alumina scale (36) and alumina scale-bond coat interface. As a result, conventional practice has been to grit blast the surface of a diffusion aluminide bond coat (24) to increase its surface roughness before depositing the TBC (26).

As reported in Appellant's specification starting on the paragraph bridging pages 9 and 10, the surface of Appellant's diffusion aluminide bond coat (24) has columnar grains (32) and is characterized by surface

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irregularities, termed grain boundary ridges, that correspond to the locations of the grain boundaries (34) as represented in Figure 2.¹ From an investigation carried out by Appellant and reported in Appellant's specification starting on the paragraph bridging pages 10 and 11, it was observed that spallation of a TBC (26) on such a bond coat (24) was brought on by a mechanism that involved convolution of the alumina scale (36), as portrayed in Figure 3. The convolutions were observed to typically initiate at the grain boundaries (34), and to further develop with oxide growth. Distinct valleys (38) formed as a result of the scale convolution eventually reached a critical depth/width ratio (Figure 4), and a crack (40) eventually formed in the scale (36) and typically propagated into the bond coat/oxide scale interface (Figure 5). The mechanism illustrated in Figures 2 through 5 of Appellant's application is described in detail in Appellant's specification starting at line 8 of page 10 and continuing to line 31 of page 11.

According to Appellant's invention, this convolution and cracking of a diffusion aluminide bond coat (24) with columnar grains (32) can be inhibited by recrystallizing the bond coat (24) to eliminate the original grain boundaries (34)

¹ As noted on page 4 of Appellant's specification in the first paragraph beneath the heading "Brief Summary of the Invention," columnar grain structures, in which grains (32) extend through the additive layer (28) such that grain boundaries (34) are exposed at the bond coat surface, are the result of such deposition methods as vapor phase aluminizing (VPA) and chemical vapor deposition (CVD).

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throughout the bond coat (24) or at least adjacent the bond coat surface, yielding new grain structures illustrated in Figures 6 through 9. In so doing, more stable grains (42,48,50) are created at the bond coat surface where the critical alumina scale-bond coat interface exists. In addition, the original surface texture of the bond coat (24) is altered to be smoother where the new grain boundaries (44,52) meet the bond coat surface. See the second and third paragraphs on page 5 of Appellant's specification. The particular type of grains (42,48,50) that form in the bond coat (24) depend on the peening intensities and whether the bond coat (24) is single-phase [(Ni,Pt)Al] or two-phase [PtAl₂+(Ni,Pt)Al]. See Appellant's specification at page 14, lines 2-20, and page 16, line 15-page 17, line 13.

On the basis of the above, Appellant's claimed method is directed to improving the life of a TBC (26) by modifying the grain structure of a diffusion aluminide bond coat (24) that adheres the TBC (26) to a surface of a component (20). The method entails depositing the bond coat (24) to have columnar grains (32) with grain boundaries (34) exposed at the surface of the bond coat (24), resulting in the surface of the bond coat (24) having surface irregularities as a result of grain boundary ridges defined by the grain boundaries (34) at the surface of the bond coat (24). At least the surface region of the bond coat (24) is then recrystallized so that new grains (42,48,50) form at the bond coat surface, replacing the original columnar grains (32),

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before or during deposition of a ceramic layer on the surface of the bond coat (24) to form the TBC (26).

As recited in independent claim 1, Appellant's claimed method requires that, as a result of recrystallization, the new grains (42,48,50) eliminate at least some of the grain boundary ridges and cause the surface of the bond coat (24) to be smoother and flatter. Consequently, the ceramic layer (TBC 26) is deposited on the smoother and flatter surface of the bond coat (24).

In addition to the limitations of independent claim 1, independent claim 11 further requires that the bond coat (24) is deposited by vapor phase aluminizing or by chemical vapor deposition, and specifies the bond coat (24) as having an additive layer (28) and diffusion zone (30). Recrystallization is recited as being carried out by peening the surface of the bond coat (24) at an intensity of at least 6A, and then heat treating the bond coat (24).

Similar to independent claim 11, independent claim 20 requires that the bond coat (24) is deposited by vapor phase aluminizing or by chemical vapor deposition, and specifies the bond coat (24) as having an additive layer (28) and diffusion zone (30). Recrystallization is recited as being carried out by peening the bond coat (24) at an intensity of 6A to 12A, and then heat treating the bond coat (24) to cause recrystallization of the entire additive layer (28) of the bond coat (24). Claim 20 further requires that the new grains (48) are equiaxed grains (48) having a grain size of about fifteen to thirty micrometers.

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In summary, Appellant teaches and claims a method for recrystallizing a columnar-grained diffusion aluminide bond coat (24) for a TBC (26) to form new grains (42,48,50) within the bond coat (24) that, in addition to replacing the original columnar grains (32) and grain boundaries (34) of the bond coat (24), also smooth and flatten the surface of the bond coat (24) by eliminating at least some of the grain boundary ridges that were defined by the original grain boundaries (34) at the surface of the bond coat (24).

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GROUND OF REJECTION TO BE REVIEWED ON APPEAL

A concise statement of each ground of rejection presented for review follows:

- a) Whether Claims 1, 4-8, and 10 are patentable over the combination of Appellant's admitted prior art (AAPA) and JP 01-180959 A to Nakamura et al. (Nakamura), applied under 35 USC §103.
- b) Whether Claims 2, 11, 13-18, and 20 are patentable over the combination of the AAPA and Nakamura in further view of U.S. Patent No. 4,514,469 to Loersch et al. (Loersch), applied under 35 USC §103.
- c) Whether Claim 3 is patentable over the combination of the AAPA and Nakamura in further view of U.S. Patent No. 4,512,817 to Duhl et al. (Duhl), applied under 35 USC §103.
- d) Whether Claim 12 is patentable over the combination of the AAPA, Nakamura, Loersch, and Duhl, applied under 35 USC §103.
- e) Whether Claim 19 is patentable over the combination of the AAPA, Nakamura, and Loersch in further view of U.S. Patent No. 5,238,752 to Duderstadt et al. (Duderstadt), applied under 35 USC §103.
- f) Whether Claim 9 is patentable over the combination of the AAPA and Nakamura in further view of U.S. Patent No. 6,210,744 to Hayess et al. (Hayess), applied under 35 USC §103.

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ARGUMENT

Rejections under 35 USC §103

Provided immediately below is a discussion of the scope and content of the prior art applied in the 35 USC §103 rejections of the claims under appeal, followed by remarks directed to the claims individually or grouped as set forth below.

Appellant respectfully traverses each of the 35 USC §103 rejections for the reason that her invention is an unobvious improvement over the prior art when evaluated under the criteria established by the Supreme Court in *Graham v. John Deere*, 148 U.S.P.Q. 459 (1966). As presented below, Appellant believes that the applied prior art, in combination, does not teach recrystallizing a diffusion aluminide bond coat for a ceramic TBC, wherein the surface of the bond coat on which the TBC is deposited is smoothed and flattened as a result of recrystallization. Instead, the applied prior art teaches away from smoothing and flattening the surface of a diffusion aluminide bond coat to promote adhesion and inhibit spallation of the TBC.

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Appellant's Admitted Prior Art ("AAPA")

The AAPA, which generally includes the teachings within the "Background of the Invention" section of Appellant's specification starting on page 2, Appellant's specification from line 8 of page 8 to line 24 of page 10, and Figures 1 through 5. The Examiner has acknowledged,² and Appellant agrees, the AAPA discloses a thermal barrier coating (TBC) system (20) comprising a diffusion aluminide bond coat (24) deposited on a component (10) so that the bond coat (24) is characterized by substantially columnar grains (32) and grain boundaries (34) exposed at the surface of the bond coat (24). The Examiner has also acknowledged that the AAPA does not teach recrystallizing any portion of the bond coat (24) during or prior to depositing a TBC (26) on the bond coat (24) so that new grains (42,48,50) form at the bond coat surface.

Relevant to this last point, the AAPA teaches that conventional practice is to intentionally smooth overlay bond coats by polishing or peening before depositing the TBC. See Appellant's specification at page 3, lines 11-33. The AAPA then contrasts the conventional treatment of diffusion aluminide bond coats as follows:

² See the Office Action dated October 22, 2004, paragraph 6, and the Office Action dated May 26, 2005, paragraph 11.

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TBC spallation initiates by a different mechanism on diffusion aluminide bond coats, and primarily along the alumina-bond coat interface. Accordingly, the toughness of the alumina and the alumina-bond coat interface are most important to TBC deposited on a diffusion aluminide bond coat. From this perspective, *polishing a diffusion aluminide bond coat would be expected to reduce TBC life, since sufficient surface roughness of the bond coat would be desired to promote adhesion of the alumina to the bond coat, and to inhibit crack propagation through the alumina and alumina-bond coat interface.* As a result, *conventional practice has been to grit blast the surface of a diffusion aluminide bond coat to increase its roughness to about 50 microinches (about 1.25 micrometers) Ra or more before depositing the TBC.* (Emphasis added.)

Paragraph bridging pages 3 and 4.

Therefore, not only does the AAPA fail to teach or suggest recrystallizing any portion of a diffusion aluminide bond coat (24) to form new grains (42,48,50) at the bond coat surface, but the AAPA teaches away from any processing (such as polishing or peening) that would result in smoothing and flattening the surface of a diffusion aluminide bond coat (24) because the result would be reduced adhesion of the TBC (26) and reduced crack resistance of the alumina scale-bond coat interface, thus promoting the spallation of the TBC (26).

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Nakamura et al. (Nakamura), Japanese document JP 01-180959 A

Nakamura pertains to corrosion-resistant coatings, and not bond coats (in other words, Nakamura's coatings do not adhere another coating, such as a ceramic TBC). Nakamura's coating can be a diffusion aluminide coating, and is peened to form "fine recrystallized grains." According to Nakamura, the advantages of peening and recrystallizing a diffusion coating used as a corrosion-resistant outer coating include improved thermal fatigue resistance without deteriorating the corrosion resistance, low crack propagation speed due to the small grain size of the recrystallized grains, and increased resistance to peeling. See Abstract. However, Nakamura does not teach or suggest that such a recrystallized coating is or could be acceptable as a bond coat for a TBC.

Loersch et al. (Loersch), U.S. Patent No. 4,514,469

Consistent with the AAPA, Loersch discloses that it is common practice to peen overlay coatings, such as MCrAlY. Loersch discusses overlay coatings deposited by physical vapor deposition (PVD) to have as-deposited grain structures with columnar grains perpendicular to the surface on which the coatings are deposited (Column 1, Lines 10-19), and that peening serves to close the vertical discontinuities and defects between the columns of the PVD

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overlay coatings and recrystallize and consolidate the coating grain boundaries (Column 1, Lines 19-35). Loersch also notes prior attempts to peen overlay coatings deposited by plasma spraying and having as-deposited characteristics such as porosity and rough surfaces. Loersch at Column 1, Line 62-Column 2, Line 19.

Loersch teaches specific peening parameters in the "Summary of the Invention" and the "Best mode for Carrying out the Invention." Loersch also teaches that peening serves to smooth the coating surfaces, thereby improving their surface finish. See, for example, Column 2, Lines 3-6.

Loersch concludes that the invention "improve[s] the properties of overlay coatings on metal workpieces, by densifying and smoothing them" (Column 2, Lines 26-28), improved properties include "density, protective properties, and surface finish" (Column 2, Lines 46-48), and "[t]he smoother surface finish provides an aerodynamically superior gas turbine airfoil, and offers improvements in other applications." From this, it is evident that Loersch's peened overlay coatings define the outermost surface of the component on which they are deposited, thereby excluding a TBC ("thermal barrier coating," "TBC," and "bond coat" are never used in Loersch). Therefore, at best, Loersch is repetitive of the AAPA's teachings regarding peening of overlay bond coats (see Appellant's specification at Page 3, Lines 6-33), and at worst limited to overlay coatings that are not intended to adhere a TBC.

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Loersch teaches nothing regarding peening of a diffusion aluminide coating.

Duhl et al. (Duhl), U.S. Patent No. 4,512,817

The relevant teachings of Duhl appear to be limited to the following passages.

Broadly, two types of coatings are employed in the gas turbine field. These are the aluminide coatings, generally produced by the interaction of aluminum compound vapors with the surface of the article to form an aluminum rich protective surface, and the overlay coatings in which a complete layer of a corrosion resistant alloy is applied to the substrate without significant interaction with the substrate. Overlay coatings can be applied by vapor deposition or by plasma spray deposition techniques. Both types of coatings are applied at moderate substrate temperatures, i.e., 1400°F-1750°F and are subsequently given a heat treatment at a higher temperature, typically 1975°F, for the purpose of improving coating uniformity and adherence. In the case of overlay coatings, mechanical working by peening is employed prior to coating heat treatment to eliminate defects. The coating heat treatment improves coating adherence (by causing a limited amount of interdiffusion between the coating and the substrate) and, in the case of overlay coatings, causes healing of coating defects in combination with a surface peening step. The amount of the interdiffusion is controlled by the time and temperature of the heat treatment, although it obviously varies with other factors such as coating and substrate composition and coating thickness. The desired amount of interdiffusion is somewhat a matter of judgement. (Emphasis added.)

Column 3, Lines 8-40.

[T]he conventional coating heat treatment at 1975°F for four hours may be replaced by a treatment at about 2050 °F for about two hours.

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Column 4, Lines 14-16.

Duel does not discuss bond coats for TBC.

In view of the above, Duhl confirms the teachings of the AAPA and Loersch that overlay coatings are improved by peening, and teaches nothing regarding peening of a diffusion aluminide coating.

Duderstadt et al. (Duderstadt), U.S. Patent No. 5,238,752

Duderstadt is directed to a TBC system that includes a TBC adhered to a superalloy substrate with a diffusion aluminide bond coat. Duderstadt discloses that nickel-base superalloys typically contain tantalum, and that tantalum tends to diffuse into the diffusion aluminide bond coat deposited on such superalloys. Column 6, Lines 14-22.

Hayess et al. (Hayess), U.S. Patent No. 6,210,744

Hayess is directed to a TBC coating process, and discloses that the temperature for a bond coat during TBC deposition may be about 900°C to about 1150°C. Column 3, Lines 1-8 and 59-60; Column 4, Line 65-Column 5, Line 12.

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Summary of Prior Art

In view of the above, Loersch and Duhl agree with the AAPA that peening is a conventional treatment for overlay coatings, and the AAPA further teaches that peening is a conventional treatment for overlay bond coats. Furthermore, the AAPA and Loersch agree that peening smooths the surface of a coating.

The only prior art relating to peening of a diffusion aluminide coating is Nakamura, which does not disclose or suggest using a peened diffusion aluminide coating as a bond coat for a TBC. Though the smoothing effect of peening is not mentioned in the brief Abstract of Nakamura available to Appellant, such an effect appears certain from the teachings of the AAPA and Loersch.

Finally, the teachings in the AAPA that it would be contrary to peen a diffusion aluminide bond coat (Page 3, Line 34-Page 4, Line 15) are unchallenged by the other prior art of record.

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(1) Rejection under 35 USC §103 over the AAPA and Nakamura

Claims 1, 4-8, and 10 were rejected over the combination of the AAPA and Nakamura on the basis that, though the AAPA does not teach recrystallizing a bond coat (24) during or prior to depositing a TBC (26) on the bond coat (24) so that new grains (42,48,50) form at the bond coat surface, Nakamura teaches

after depositing a diffusion coating layer of Al (i.e., an aluminide bond coat) on the surface of a gas turbine component such as a blade (i.e., a process analogous to that taught by the AAPA), the diffusion coating layer is shot-peened and then heated to a temperature at or above the recrystallization temperature of the coating layer, thereby causing recrystallized grains (i.e., "new grains") to form on the surface of the diffusion coating layer (Abstract).

Office Action of October 22, 2004, paragraph 6.

From this, the Examiner concluded that it would have been obvious to a person having ordinary skill in the art at the time the invention was made

to improve the thermal fatigue life of the TBC system of the AAPA . . . as taught by Nakamura et al., with the reasonable expectation of successfully and advantageously providing the coated superalloy component/blade of the AAPA with [benefits].

Office Action of October 22, 2004, paragraph 6.

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However, from the above discussions of the AAPA and Nakamura, Appellant believes that neither the AAPA nor Nakamura teaches or suggests smoothing, flattening, and recrystallizing a diffusion aluminide bond coat on which a ceramic TBC is to be deposited and adhered. Instead, the only teachings on this point are those of the AAPA, which teaches away from smoothing and flattening the surface of a diffusion aluminide bond coat because doing so will reduce the adhesion of a TBC and the crack resistance of the alumina scale-bond coat interface, thus promoting the spallation of the TBC.

In the "Response to Arguments" section of the Office Action of October 22, 2004, the Examiner provided a detailed explanation for maintaining this rejection. In particular, the Examiner presented reasons why he believed those of ordinary skill in the art would find Nakamura to be relevant to Appellant's claimed invention and be the basis of a reasonable expectation of success.

In response, Appellant submitted the attached Rule 132 Declaration (filed February 22, 2005), in which she provided direct responses to the reasons given for maintaining the rejection. Briefly, Appellant Irene Spitsberg explained:

(1) the differences between the failure mechanism that Nakamura attempts to address by peening and the failure mechanism that Appellant and

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others in the TBC art must address if attempting to solve the problem of TBC spallation, and provided ample proof to rebut the Examiner's conclusion that previous arguments made by Appellant concerning this issue were merely based on "speculation"; and

(2) why those of ordinary skill in the art do not and would not view the "peeling-off, thermal fatigue, cracking and crack propagation, etc." in a diffusion coating that was addressed by Nakamura is in any way related to TBC spallation in diffusion aluminide bond coat-based TBC systems such as the AAPA.

Appellant's Declaration established that she is an expert in the relevant art, particularly in regard to the spallation mechanisms of TBC systems, and is therefore qualified to provide opinions as to the conventional wisdom in the art, including what those skilled in the art believe and what those skilled in the art would conclude from the teachings of Nakamura. In particular, Appellant's expert opinion was that, without the benefit of her teachings:

- one of ordinary skill in the art would not be motivated to try the proposed modification because the failure mechanism addressed by Nakamura is unrelated to the failure mechanism associated with TBC spallation and addressed by Appellant's invention; and
- one of ordinary skill in the art would not have any reasonable expectation that peening the surface of a diffusion aluminide bond coat would

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improve the thermal fatigue life of a thermal barrier coating deposited on the bond coat.

Finally, the lack of a reasonable expectation of success is evident from the applied prior art itself. Specifically, the AAPA (and Loersch) teaches that peening causes smoothing of a coating surface, and the AAPA also teaches that

sufficient surface roughness of the bond coat would be desired to promote adhesion of the alumina to the bond coat, and to inhibit crack propagation through the alumina and alumina-bond coat interface. As a result, conventional practice has been to grit blast the surface of a diffusion aluminide bond coat to increase its roughness

Nothing in Nakamura refutes this as the conventional wisdom in the art of TBC systems. Therefore, Appellant believes the AAPA and Nakamura are not properly combinable as prior art references under 35 USC §103 because the AAPA teaches away from any treatment (such as Nakamura's) that would result in smoothing and flattening a diffusion aluminide bond coat. *In re Lintner*, 173 USPQ 560, 562 (CCPA 1972); *In re Regel*, 188 USPQ 136 (CCPA 1972); *In re Jansson*, 203 USPQ 976 (CCPA 1979).

At this point, Appellant wishes to reemphasize that:

- Overlay and diffusion aluminide coatings are chemically and physically different and therefore employ different processing during and after their deposition (e.g., the AAPA and Duhl);

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- Overlay coatings that serve as the outermost surface of a component benefit from having a smooth outer surface to promote the aerodynamic properties of the component (e.g., Loersch);
- Peening is known and used to smooth and flatten coatings and other surfaces (e.g., the AAPA, Loersch, and Duhl);
- Overlay and diffusion aluminide coatings that serve as bond coats for TBC's must promote adhesion of the TBC (e.g., the AAPA).

According to the only prior art of record relating to the last point (the AAPA), while overlay bond coats can benefit from being smoothed, flattened, and recrystallized (e.g., by peening or polishing), the prior art of record lacks even the remotest suggestion that TBC adhesion to a diffusion aluminide bond coat would improve from smoothing, flattening, and recrystallizing the bond coat by peening or any other process. To the contrary, the AAPA teaches that smoothing and flattening a diffusion aluminide bond coat would be detrimental to adhesion of a TBC, and that its adhesion and spallation mechanisms differ from overlay bond coats. Therefore, it is only through the results of Appellant's application that smoothing, flattening, and recrystallizing a diffusion aluminide bond coat would be concluded as having a reasonable expectation of success under *In re Vaeck*, 20 USPQ2d 1438 (Fed. Cir. 1991).

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Finally, Appellant notes that, though the Examiner cites various grounds for arguing why one skilled in the art would be motivated to modify the AAPA on the basis of Nakamura and have a reasonable expectation of success in doing so, the Examiner never addresses the smoothing/flattening issue. Therefore, the Examiner has not explained how the benefits of peening a diffusion aluminide coating ascribed by Nakamura - and whose transferability to diffusion aluminide bond coats is speculative - rebuts the explicit teaching of the AAPA that smoothing a diffusion aluminide bond coat is detrimental to TBC adhesion based on the spallation mechanism explained in detail in the AAPA.

In summary, without the benefit of Appellant's teachings, those skilled in the art would conclude that peening and recrystallizing a diffusion aluminide coating according to Nakamura would smooth the coating surface according to the AAPA (and Loersch), and therefore would be detrimental to the suitability of the coating as a bond coat for the reasons taught by the AAPA. Appellant therefore respectfully requests that this Honorable Board of Appeals reverse the Examiner's rejection of claims 1, 4-8, and 10 under 35 USC §103(a) based on the AAPA and Nakamura.

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(2) Rejection under 35 USC §103 over the AAPA, Nakamura, and Loersch

Claims 2, 11, 13-18, and 20 were rejected over the combination of the AAPA, Nakamura, and Loersch on the basis that, though the combination of the AAPA and Nakamura does not teach inducing recrystallization by peening at intensities of at least 6A, Loersch does.

However, from the above discussion of the rejection based on the AAPA and Nakamura, Appellant believes that Loersch's disclosure of peening overlay coatings to close vertical discontinuities and defects and recrystallize and consolidate the coating grain boundaries does not overcome the teachings of the AAPA, which already acknowledges that peening of overlay bond coats is entirely conventional, but that peening to smooth, flatten, and recrystallize a diffusion aluminide bond coat has not been performed based on the conventional wisdom that doing so would reduce adhesion of a TBC and the crack resistance of the alumina scale-bond coat interface, thus promoting spallation of the TBC.

As nothing in Loersch disputes this teaching, Loersch does nothing to alter the conclusion that, without the benefit of Appellant's teachings, those skilled in the art would conclude that peening and recrystallizing a diffusion aluminide coating according to Nakamura would smooth the coating surface

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according to the AAPA and Loersch, and therefore would be detrimental to the suitability of the coating as a bond coat for the reasons taught by the AAPA.

Appellant therefore respectfully requests that this Honorable Board of Appeals reverse the Examiner's rejection of claims 2, 11, 13-18, and 20 under 35 USC §103.

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(3) Rejection under 35 USC §103 over the AAPA, Nakamura, and Duhl

Claim 3 was rejected over the combination of the AAPA, Nakamura, and Duhl on the basis that, though the combination of the AAPA and Nakamura does not teach heating a bond coat to a temperature of about 1090°C to about 1120°C, Duhl does.

However, from the above discussion of the rejection based on the AAPA and Nakamura, Appellant believes that Duhl's disclosure of a heat treatment temperature range does not overcome the teachings of the AAPA that smoothing, flattening, and recrystallizing a diffusion aluminide bond coat has not been performed based on the conventional wisdom that doing so would reduce the adhesion of a TBC and the crack resistance of the alumina scale-bond coat interface, thus promoting spallation of the TBC.

As nothing in Duhl disputes this teaching, Duhl does nothing to alter the conclusion that, without the benefit of Appellant's teachings, those skilled in the art would conclude that peening and recrystallizing a diffusion aluminide coating according to Nakamura would smooth the coating surface according to the AAPA (and Loersch), and therefore would be detrimental to the suitability of the coating as a bond coat for the reasons taught by the AAPA.

Appellant therefore respectfully requests that this Honorable Board of Appeals reverse the Examiner's rejection of claim 3 under 35 USC §103.

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**(4) Rejection under 35 USC §103 over the AAPA, Nakamura, Loersch,
and Duhl**

Claim 12 was rejected over the combination of the AAPA, Nakamura, Loersch, and Duhl on essentially the same grounds as the rejection addressed in paragraph (3) above, namely, though the combination of the AAPA, Nakamura, and Loersch does not teach heating a bond coat to a temperature of about 1090°C to about 1120°C, Duhl does. Because, as explained in paragraph (3) above, nothing in Duhl disputes the teaching of the AAPA that smoothing, flattening, and recrystallizing a diffusion aluminide bond coat would be detrimental to the adhesion of a TBC, Duhl does nothing to alter the conclusion that, without the benefit of Appellant's teachings, those skilled in the art would conclude that peening and recrystallizing a diffusion aluminide coating according to Nakamura would smooth the coating surface according to the AAPA and Loersch, and therefore would be detrimental to the suitability of the coating as a bond coat for the reasons taught by the AAPA.

Appellant therefore respectfully requests that this Honorable Board of Appeals reverse the Examiner's rejection of claim 12 under 35 USC §103.

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**(5) Rejection under 35 USC §103 over the AAPA, Nakamura, Loersch,
and Duderstadt**

Claim 19 was rejected over the combination of the AAPA, Nakamura, Loersch, and Duderstadt on the basis that, though the combination of the AAPA, Nakamura, and Loersch does not teach that nickel-base superalloys typically contain tantalum that tends to diffuse into a diffusion aluminide bond coat deposited on such superalloys, Duderstadt does. However, in view of Appellant's discussion of the rejection based on the AAPA, Nakamura, and Loersch, Appellant believes that Duderstadt's disclosure of the tendency for tantalum to be present in a diffusion aluminide bond coat does not overcome the teachings of the AAPA, Loersch, and Duhl that peening serves to smooth a coating, or the teachings of the AAPA that smoothing, flattening, and recrystallizing a diffusion aluminide bond coat has not been performed based on the conventional wisdom that doing so would reduce the adhesion of a TBC and the crack resistance of the alumina scale-bond coat interface, thus promoting spallation of the TBC.

As nothing in Duderstadt disputes this teaching, Duderstadt does nothing to alter the conclusion that, without the benefit of Appellant's teachings, those skilled in the art would conclude that peening and recrystallizing a

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diffusion aluminide coating according to Nakamura would smooth the coating surface according to the AAPA and Loersch, and therefore would be detrimental to the suitability of the coating as a bond coat for the reasons taught by the AAPA.

Appellant therefore respectfully requests that this Honorable Board of Appeals reverse the Examiner's rejection of claim 19 under 35 USC §103.

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(6) Rejection under 35 USC §103 over the AAPA, Nakamura, and Hayess

Claim 9 was rejected over the combination of the AAPA, Nakamura, and Hayess on the basis that, though the combination of the AAPA and Nakamura does not teach a bond coat temperature during deposition of a TBC of about 900°C to about 1150°C, Hayess does. However, in view of Appellant's discussion of the rejection based on the AAPA and Nakamura, Appellant believes that Hayess' disclosure of a bond coat temperature during TBC deposition does not overcome the teachings of the AAPA, Loersch, and Duhl that peening serves to smooth a coating, or the teachings of the AAPA that smoothing, flattening, and recrystallizing a diffusion aluminide bond coat has not been performed based on the conventional wisdom that doing so would reduce the adhesion of a TBC and the crack resistance of the alumina scale-bond coat interface, thus promoting spallation of the TBC.

As nothing in Hayess disputes this teaching, Hayess does nothing to alter the conclusion that, without the benefit of Appellant's teachings, those skilled in the art would conclude that peening and recrystallizing a diffusion aluminide coating according to Nakamura would smooth the coating surface according to the AAPA (and Loersch), and therefore would be detrimental to the suitability of the coating as a bond coat for the reasons taught by the AAPA.

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Appellant therefore respectfully requests that this Honorable Board of Appeals reverse the Examiner's rejection of claim 9 under 35 USC §103.

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CLOSING

For all of the above reasons, Appellant respectfully requests that this Honorable Board of Appeals reverse the Examiner's rejections of claims 1-20 under 35 USC §103.

Respectfully submitted,

By

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January 26, 2006
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Attachments: Claims Appendix; Evidence Appendix; Related Proceedings Appendix

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Claim Appendix

Claim 1: A method of improving the thermal fatigue life of a thermal barrier coating by modifying the grain structure of a diffusion aluminide bond coat that adheres the thermal barrier coating to a surface of a superalloy component, the method comprising the steps of:

depositing the aluminide bond coat on the component so as to be characterized by substantially columnar grains that extend substantially through that portion of the aluminide bond coat overlying the surface of the component, the grains having grain boundaries exposed at the surface of the aluminide bond coat, the surface of the aluminide bond coat having surface irregularities as a result of grain boundary ridges defined by the grain boundaries at the surface of the aluminide bond coat; and then

recrystallizing at least a surface region of the aluminide bond coat during or prior to depositing the thermal barrier coating on the surface of the aluminide bond coat, wherein new grains form at the surface of the aluminide bond coat and a ceramic layer is deposited on the surface of the aluminide bond coat to form the thermal barrier coating;

wherein following the recrystallizing step the new grains cause the surface of the aluminide bond coat to be smoother and flatter as a result of

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eliminating at least some of the grain boundary ridges, whereby the ceramic layer is deposited on the smoother and flatter surface of the aluminide bond coat.

Claim 2: A method according to claim 1, wherein recrystallization is induced by peening the aluminide bond coat at an intensity of at least 6A prior to heating the aluminide bond coat.

Claim 3: A method according to claim 1, wherein the aluminide bond coat is heated to a temperature of about 1090°C to about 1120°C during the recrystallizing step.

Claim 4: A method according to claim 1, wherein the new grains have a grain size of not smaller than five micrometers after recrystallization.

Claim 5: A method according to claim 1, wherein the new grains are substantially equiaxed.

Claim 6: A method according to claim 5, wherein the aluminide bond coat is a single-phase or two-phase aluminide prior to recrystallization.

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Claim 7: A method according to claim 1, wherein precipitates are present in the grain boundaries of the grains after the depositing step and before recrystallization, and the precipitates are substantially absent from grain boundaries of the new grains after recrystallization.

Claim 8: A method according to claim 7, wherein the aluminide bond coat is a single-phase aluminide after recrystallization.

Claim 9: A method according to claim 1, wherein recrystallization of at least the surface region of the aluminide bond coat occurs during deposition of the thermal barrier coating on the surface of the aluminide bond coat.

Claim 10: A method according to claim 1, wherein the aluminide bond coat is a platinum aluminide bond coat.

Claim 11: A method of improving the thermal fatigue life of a thermal barrier coating by modifying the grain structure of a diffusion aluminide bond coat that adheres the thermal barrier coating to a surface of a superalloy component, the method comprising the steps of:

depositing the aluminide bond coat on the component by vapor phase aluminizing or by chemical vapor deposition, the aluminide bond coat

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comprising an additive layer on the surface of the component and a diffusion zone in a surface region of the component, the additive layer being characterized by columnar grains that extend from the diffusion zone to the surface of the aluminide bond coat, the grains having grain boundaries exposed at the surface of the aluminide bond coat, the surface of the aluminide bond coat having surface irregularities as a result of grain boundary ridges defined by the grain boundaries at the surface of the aluminide bond coat;

peening the surface of the aluminide bond coat at an intensity of at least 6A; and then

heat treating the aluminide bond coat before or while depositing the thermal barrier coating on the surface of the aluminide bond coat so as to recrystallize at least a surface region of the aluminide bond coat, wherein new grains form within the additive layer at the surface of the aluminide bond coat, the new grains causing the surface of the aluminide bond coat to be smoother and flatter as a result of eliminating at least some of the grain boundary ridges and a ceramic layer is deposited on the smoother and flatter surface of the aluminide bond coat to form the thermal barrier coating.

Claim 12: A method according to claim 11, wherein the aluminide bond coat is heat treated at a temperature of about 1090°C to about 1120°C.

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Claim 13: A method according to claim 11, wherein the new grains have a grain size of not smaller than five micrometers after the thermal barrier coating has been deposited.

Claim 14: A method according to claim 11, wherein the new grains are substantially equiaxed.

Claim 15: A method according to claim 14, wherein the aluminide bond coat is a single-phase or two-phase aluminide prior to recrystallization.

Claim 16: A method according to claim 11, wherein precipitates are substantially absent from grain boundaries of the new grains after recrystallization.

Claim 17: A method according to claim 16, wherein the aluminide bond coat is a single-phase aluminide after recrystallization.

Claim 18: A method according to claim 11, wherein the aluminide bond coat is a platinum aluminide bond coat.

Claim 19: A method according to claim 11, wherein tantalum-rich

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precipitates are present in the grain boundaries of the grains after the depositing step and before recrystallization, and the tantalum-rich precipitates are substantially absent from grain boundaries of the new grains after recrystallization.

Claim 20: A method of improving the thermal fatigue life of a thermal barrier coating by modifying the grain structure of a diffusion aluminide bond coat that adheres the thermal barrier coating to a surface of a superalloy component, the method comprising the steps of:

depositing the diffusion aluminide bond coat on the component by vapor phase aluminizing or by chemical vapor deposition, the diffusion aluminide bond coat comprising an additive layer on the surface of the component and a diffusion zone in a surface region of the component, the additive layer being characterized by columnar grains that extend from the diffusion zone to the surface of the diffusion aluminide bond coat, the grains having grain boundaries exposed at the surface of the diffusion aluminide bond coat, the surface of the diffusion aluminide bond coat having surface irregularities as a result of grain boundary ridges defined by the grain boundaries at the surface of the diffusion aluminide bond coat;

peening the diffusion aluminide bond coat at an intensity of 6A to 12A;
heat treating the diffusion aluminide bond coat at a temperature and

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for a duration sufficient to cause recrystallization of the entire additive layer of the diffusion aluminide bond coat, wherein equiaxial grains form within the additive layer, the equiaxed grains causing the surface of the diffusion aluminide bond coat to be smoother and flatter as a result of eliminating at least some of the grain boundary ridges; and then

depositing a ceramic layer on the surface of the diffusion aluminide bond coat to form the thermal barrier coating on the diffusion aluminide bond coat;

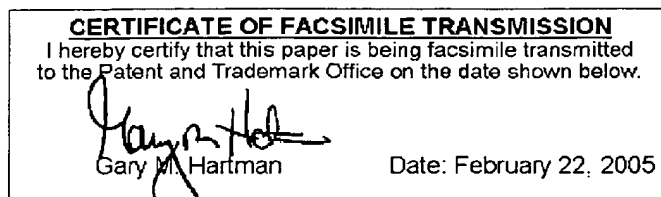
wherein the equiaxed grains have a grain size of about fifteen to thirty micrometers.

Claims 21-39 (canceled)

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Evidence Appendix

Appellant's Rule 132 Declaration, entered February 22, 2005 (number of pages: 19).

OFFICIAL

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No. : 09/524,227 Confirmation No. **6813**
Applicant : Irene T. Spitsberg
Filed: : March 13, 2000
TC/Art Unit: : 1762
Examiner : Wesley D. Markham

Docket No. : 13DV-13004
Customer No. : 30952

Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

DECLARATION UNDER 37 CFR §1.132

I, IRENE SPITSBERG, depose and say that:

(1) I am the sole inventor of the subject matter covered by the claims pending in the above-identified patent application ("Application").

(2) I was granted a Ph.D. in Physics of Solids and Metallurgy in 1994 from the Moscow Institute of Steel and Alloys.

(3) I have been continuously employed as an engineer with

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General Electric Company, GE Aircraft Engines, since 1997, and during the course of my employment have been engaged in the research and development of coating systems for components of gas turbine engines.

(4) In the last five years, I have been an inventor on twenty-six issued US patents and a named inventor for additional US patent applications, all relating to coating systems for components of gas turbine engines.

(5) In an Office Action dated October 22, 2004, claims 1-20 of the Application were rejected for a second time under 35 USC §103 as unpatentable over prior art described in the Application ("applicant's admitted prior art," or AAPA) in view of Japanese patent JP 01-180959 A to Nakamura et al. (Nakamura), either alone or in further view of one or more of U.S. Patent Nos. 4,514,469 to Loersch et al., 4,512,817 to Duhl et al., 6,042,898 to Burns et al., and 6,365,236 to Maloney.

(6) This Declaration is being submitted for the purpose of addressing arguments made in the "Response to Arguments" section of the Office Action, in which the Examiner explained why the §103 rejections were maintained in spite of arguments made in an applicant's response filed August

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4, 2004. Passages from the Examiner's "Response to Arguments" are reproduced below, each followed by my comments.

The examiner has carefully considered the aforementioned arguments, but they are not convincing for the following reasons. The crux of the applicant's argument is that Nakamura's teachings concern improving the properties of a diffusion aluminide coating, and the problems associated with a diffusion aluminide coating do not exist in the AAPA's TBC system because the TBC system does not fail due to a failure of the diffusion aluminide bond coat. In response, this argument (i.e., that the problems associated with a diffusion aluminide coating do not exist in the AAPA's TBC system) appears to be based on speculation on the part of the applicant and is not supported by evidence of record.

Page 23, Paragraph 20, of the Office Action.

(7) Nakamura is applied by the Examiner as disclosing that thermal fatigue causes cracks to form in and propagate through a diffusion aluminide coating, which results in failure of the coating by "peeling." I am not aware of anything in the technical literature which supports Nakamura's theory that diffusion coatings fail as a result of cracks propagating through the coating (i.e., in the plane of the coating). Instead, myself and others in the technical community have observed failure of a diffusion coating as the result of rapid oxidation of the diffusion zone beneath the coating, and that rapid oxidation is the result of oxidizing agents penetrating grain boundary cracks initiated at and promoted by the columnar grain boundaries of the diffusion coating. While I

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and others have attributed cracking of diffusion coatings on field-returned airfoils to thermal or mechanical fatigue, these cracks are observed to form along the columnar grain boundaries of the coatings (i.e., vertical (normal) to the substrate surface), and therefore do not result in peeling of the diffusion coating. These vertical cracks opened paths for oxidizing agents, resulting in oxidation and cracking of the diffusion zone beneath the diffusion coating. (The diffusion zone is prone to oxidation as a result of being enriched with oxygen-reactive elements such as Ta, W, Re, etc., depending on the composition of the substrate.) This failure process is depicted schematically in Figure 1, attached as Exhibit A. An illustrative case of such a process in a field-returned airfoil is shown in Figures 2 through 4, attached as Exhibit B. From this, I believe that the technical community does not agree with the theory that peeling of a diffusion coating is the result of crack propagation through the coating.

(8) Aside from any debate over failure mechanisms in diffusion coatings, I believe it is now generally accepted in the technical community that spallation of a TBC system employing a diffusion coating as a bond coat (i.e., a diffusion bond coat) is related to cracking of the alumina scale that forms on the surface of the diffusion bond coat (see the list of references attached as Exhibit H). Therefore, TBC spallation involves a failure mechanism that takes place

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above the diffusion bond coat, and not within the diffusion bond coat itself. I have systematically demonstrated this failure mechanism, which is activated and enabled by the existence of mechanical stress concentrators at the "ridges" formed by the columnar grain boundaries of a diffusion bond coat, i.e., at the surface of the bond coat. These stress concentrators serve as the driving force for plastic deformation (not cracking) of the bond coat where bond coat grain boundaries intersect the bond coat surface. The localized plastic deformation imposes stresses on a TBC deposited on the bond coat, causing the TBC and/or the alumina scale to crack horizontally. This process is illustrated in Figures 5 and 6, attached as Exhibits C and D.

(9) I believe that the above evidences that at no point during the TBC spallation process does cracking of the bond coat occur, and therefore the failure mechanism that leads to TBC spallation does not relate in any way to thermal fatigue cracking of a diffusion coating (the problem addressed by Nakamura). Furthermore, I believe there is ample evidence to argue that the problems described by Nakamura as being associated with diffusion aluminide coatings do not exist in the AAPA's TBC system. I and other experts in this field have observed and concluded that deformation of the diffusion bond coat causes horizontal cracking of the TBC and/or alumina scale, both of which are

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above the bond coat. Because bond coat cracking does not play a role in spallation of TBC deposited on a diffusion bond coat, I and others concerned with TBC spallation would not consider Nakamura's peening and recrystallization process to be relevant or useful.

The applicant's TBC system, as claimed and disclosed, comprises a diffusion aluminide bond coat. As such, one of ordinary skill in the art would have reasonably expected that problems (e.g., peeling-off, thermal fatigue, cracking and crack propagation, etc.) typically associated with diffusion aluminide coatings would be extremely relevant to diffusion aluminide bond coat-based TBC systems, such as that of the AAPA. As admitted by the applicant, Nakamura's teachings concern improving the thermal fatigue resistance, reducing crack propagation speed, and increasing the peel-off resistance of a diffusion aluminide coating. Since the TBC system of the AAPA comprises such a diffusion aluminide coating, one of ordinary skill in the art would have been highly motivated to apply Nakamura's teachings to the AAPA's TBC system.

Pages 23-24, Paragraph 20, of the Office Action.

(10) I believe that the Examiner's above conclusions are incorrect in view of the evidence that I have presented with my explanation in previous paragraphs (7)-(9). Simply stated, the technical community that has studied TBC spallation would not consider Nakamura's recrystallization process, since the benefits of Nakamura's process are intended to address problems that are not observed in TBC systems. Instead of concern for thermally-induced

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horizontal cracking of diffusion coatings (as is Nakamura), or concern for vertical cracking and oxidation of diffusion coatings (as are others that have studied non-TBC diffusion coating failures), the concern of those that have studied TBC system spallation is the horizontal cracking of the TBC and alumina scale that lie above a diffusion bond coat.

(11) Critical to the current invention were my observations and judgment that: (a) the grain boundaries of a diffusion coating form ridges on the coating surface; (b) these ridges may have a critical aspect ratio to cause the stress concentrations to drive plastic deformation at their locations; and (c) plastic deformation is the key to the TBC spallation mechanism. None of these conclusions are suggested or can be derived from Nakamura or any of the other prior art of record. So, it seems very clear that the diffusion coating cracking mechanism of Figures 1 through 4 (Exhibits A and B) and Nakamura's shot peening process as a means of suppressing cracking of a diffusion coating would not provide any motivation to peen a diffusion bond coat to inhibit TBC spallation. It could arguably have been the case if cracking and oxidation of a diffusion bond coat was the reason for TBC spallation. But it is not, as far as I am aware from the available literature (Exhibit H) and based on my observations (e.g., Exhibits C and D).

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(12) It can be further stated that my goal of using peening was to achieve a certain degree of bond coat surface planarity. As such, it was not apparent or even predictable as to the surface geometry of the grain boundary ridges that would result from peening and recrystallization. It was only through experimenting that peening was found to be suitable and capable of altering the grain boundary ridges to produce a surface geometry that inhibits TBC spallation. So, it can be seen that peening was applied for a specific and unique purpose (as opposed to a generic purpose), this purpose was different from Nakamura's purpose of abating mechanical fatigue, and the effect of my peening technique was not predictable.

Additionally, the examiner notes that the applicant's position and argument that, in the TBC-system of the AAPA, the TBC spalls as a result of cracks within an alumina scale that grows on the bond coat and/or at the interface between the bond coat and alumina scale, not as a result of cracks propagating through the diffusion aluminide bond coat, does not appear to be entirely accurate. In the sentence bridging pages 2 and 3 of the applicant's specification, the applicant states that, "...TBC deposited on diffusion aluminide bond coats typically spall at the alumina-to-bond coat interface or within the alumina layer itself". This statement clearly indicates that, in some cases, the TBC deposited on diffusion aluminide bond coats spalls at other locations. As such, one of ordinary skill in the art would have looked to improve the properties of each layer/coating in the TBC system of the AAPA to reduce the chances that failure would occur at any point in the system. (Original emphasis.)

Page 24, Paragraph 20, of the Office Action.

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Reply to Office Action of October 22, 2004

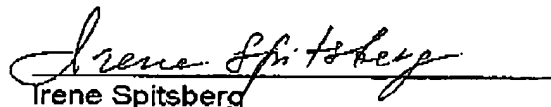
(13) The statement cited by the Examiner from the Application that the TBC can spall at "other locations" was unfortunately too generic, and therefore open to misinterpretation. As I have stated here, it is generally accepted that TBC spallation on a diffusion bond coat occurs as a result of horizontal cracks developing in the TBC and/or the alumina scale. As reported in the references listed in Exhibit H, three known scenarios are for cracks to develop at (a) the TBC-alumina scale interface, (b) the alumina scale-bond coat interface, and/or (c) a combination of the two, in which case a crack propagates through the TBC and the alumina scale. Examples of these three crack propagation paths are shown in Figures 5 through 15 (Exhibits E, F, and G). The particular crack propagation path appears to depend on the surface preparation and coating processes used, but all generally have the same detrimental effect on TBC life. Regardless of the crack path, the driving force for the cracks is still the same - stress concentration at the bond coat surface ridges.

(14) The motivation to "improve the properties of each layer/coating," as stated by the examiner, is not clear to me. One must first specify which properties must be improved, and then consider whether "improving" a property of one layer could have an unintended negative effect on

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a second layer. Where the motivation is to improve properties that affect TBC performance, numerous properties of the individual TBC layers (e.g., the thermal conductivity of the bond coat) would not appear to have any affect. From my explanation here, it is apparent that thermal fatigue resistance of a diffusion coating (Nakamura, who does not appear to address diffusion coatings used as bond coats) is another property that would not appear to have any affect on TBC performance. Therefore, Nakamura would not have provided me with any motivation to peen a diffusion bond coat to improve TBC performance.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.


Irene Spitsberg

Attachments: Exhibits A through H

EXHIBIT A

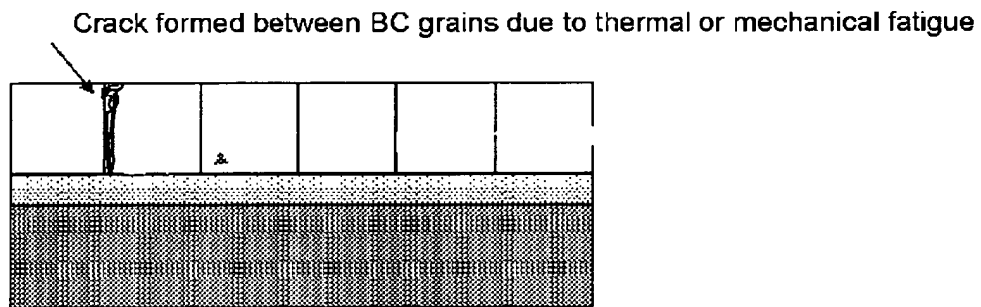


Figure 1

EXHIBIT B

Figure 2

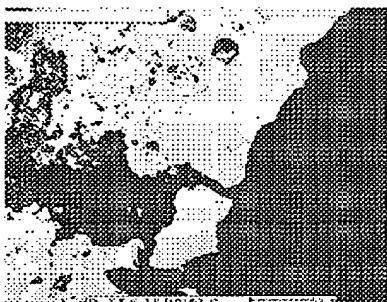


Figure 3

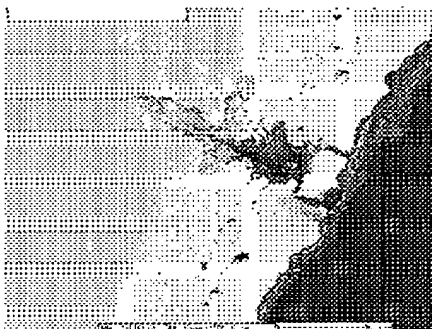


Figure 4

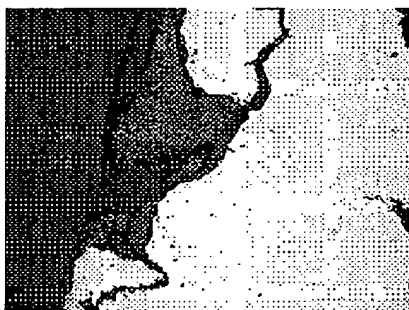


EXHIBIT C

Figure 5

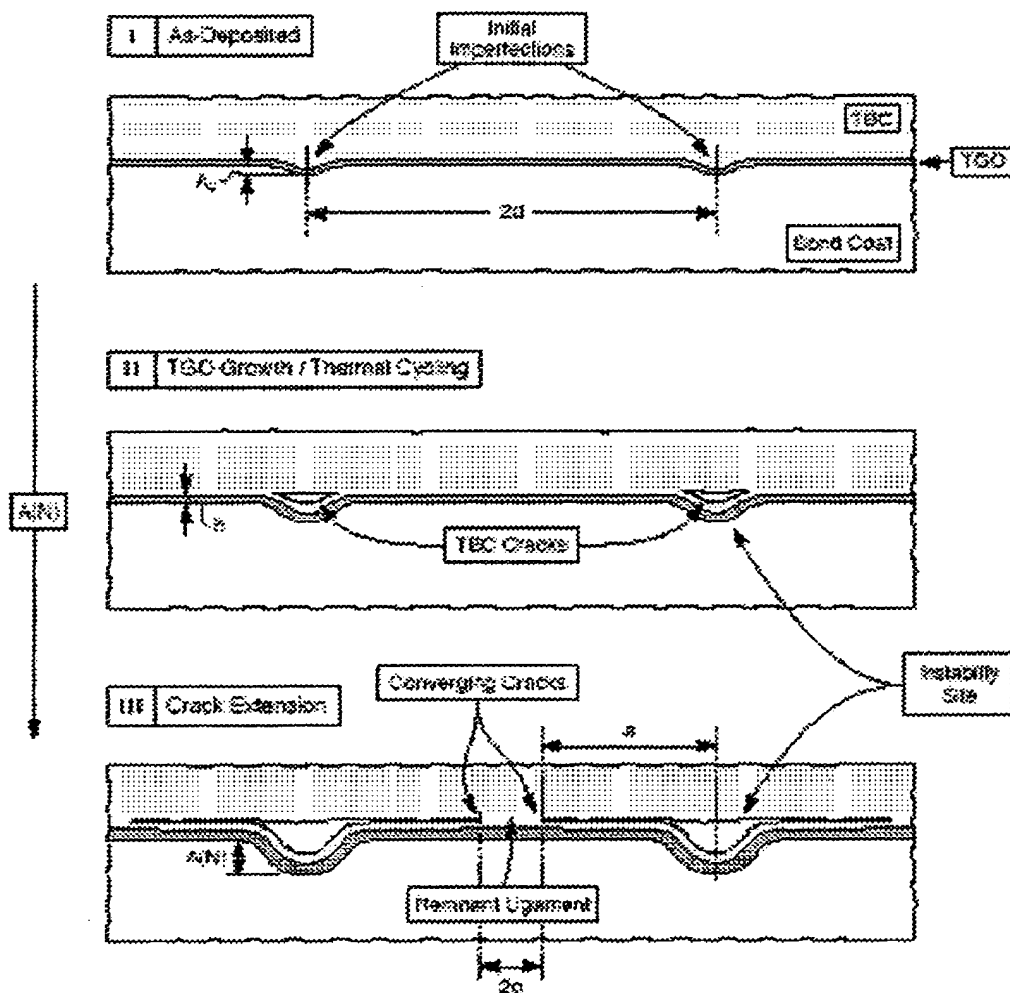


EXHIBIT D

Figure 6

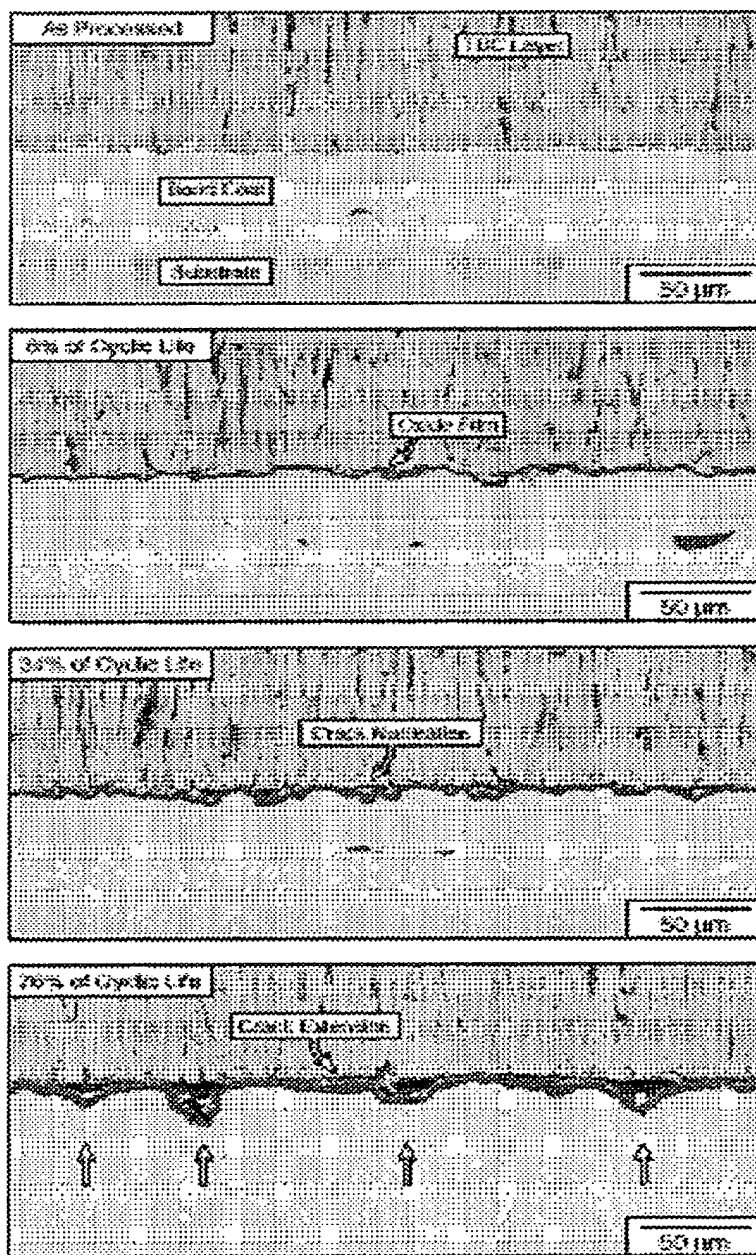


EXHIBIT E

Bond coat deformation and damage
accumulation preceding spallation

Figure 8

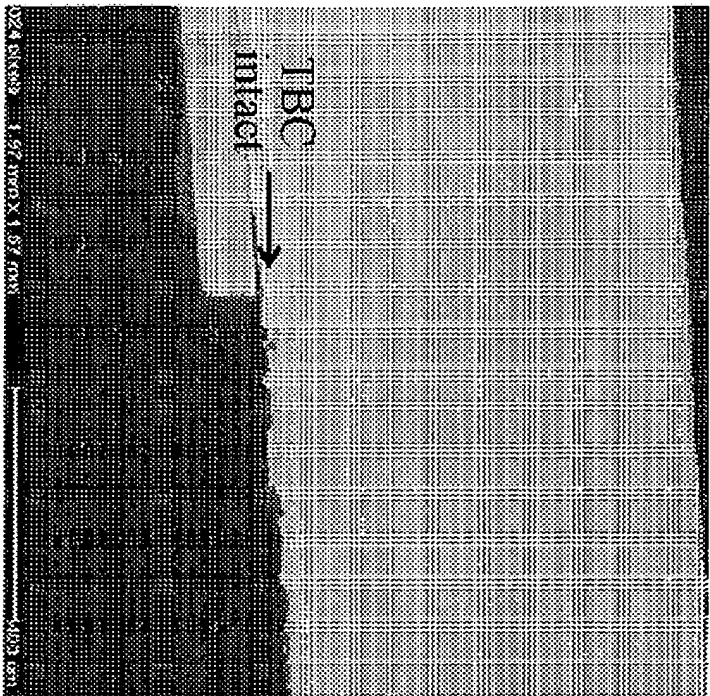
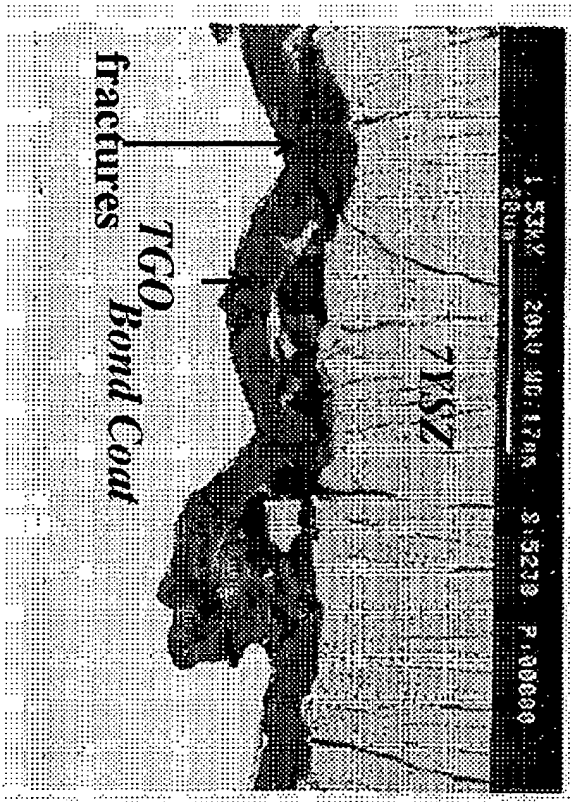


Figure 7



TBC Failure in Short Cycle Engines

EXHIBIT F

Crack propagation and degradation of interfaces Figure 9

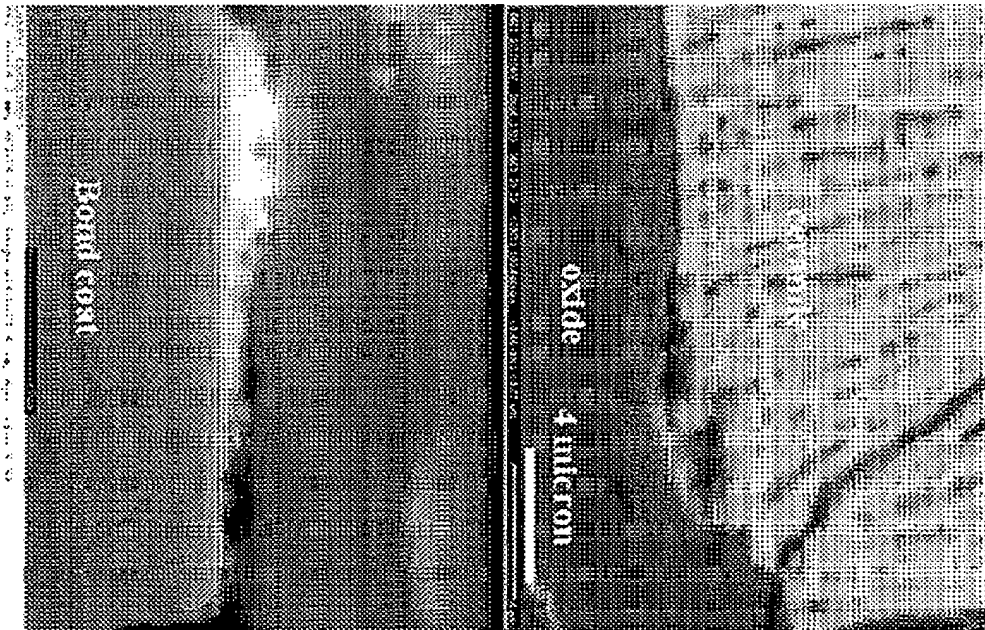


Figure 10

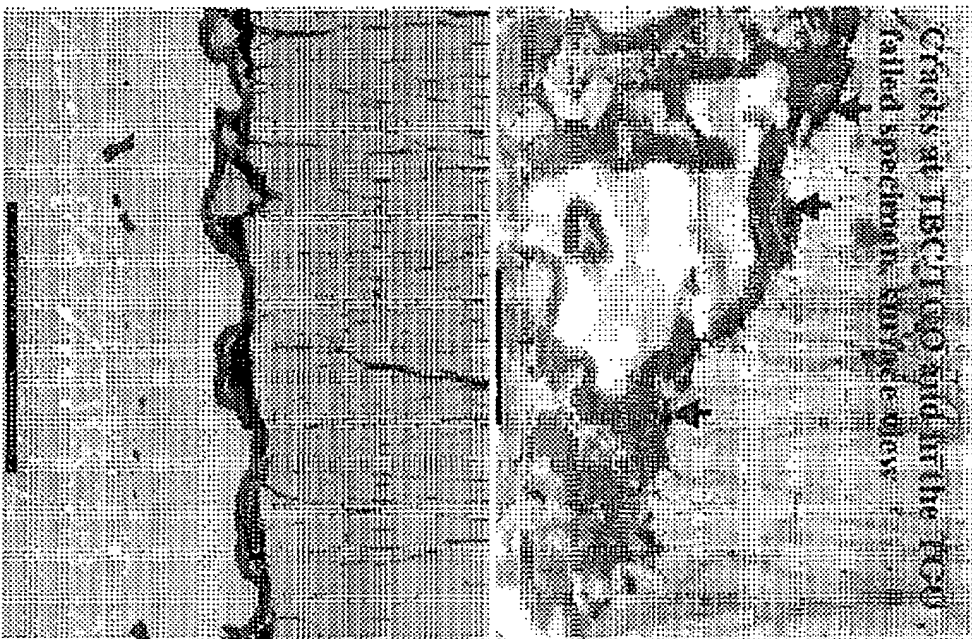


Figure 12

EXHIBIT G

Failure mode, originally not grit blasted surface

Figure 13

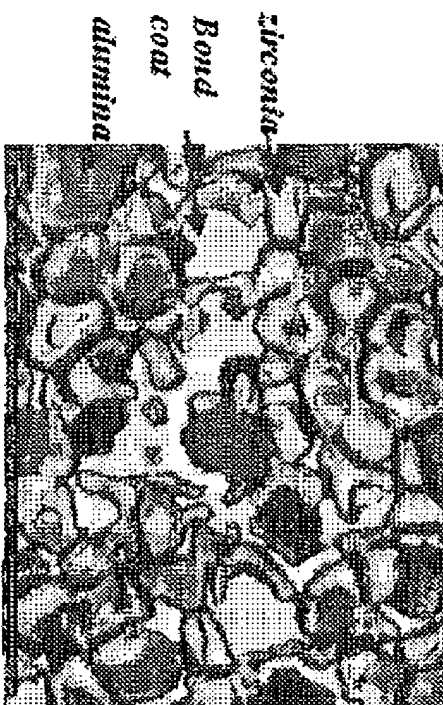


Figure 14



Predominate interface of failure can vary

Figure 15



EXHIBIT H

References

I.T. Spitsberg, "On failure mechanisms of TBC s with diffusion - aluminide bond coats," presented at Americal Society Meeting in 2000 and at ICMCTF in 2001 system.

D.R. Mumm, A.G. Evans and I.T. Spitsberg, "Characterization of a Cyclic Displacement Instability for a Thermally Grown Oxide in a Thermal Barrier System," *Acta Materialia*, **49**[12], 2329-2340 (2001).).

I.T. Spitsberg*, D. R. Mumm** and A. G. Evans,*** "On the Failure Mechanisms of Thermal Barrier Coatings with Diffusion Aluminide Bond Coatings," – *in press*.

M.Y. He, A.G. Evans and J.W. Hutchinson, "The Ratcheting of Compressed Thermally Grown Thin Films on Ductile Substrates," *Acta Materialia*, **48**[10], 2593-2601 (2000).

A.M. Karlsson and A.G. Evans, "A Numerical Model for the Cyclic Instability of Thermally Grown Oxides in Thermal Barrier Systems," *Acta Materialia*, **49**[10], 1793-1804 (2001).

M.Y. He, J.W. Hutchinson and A.G. Evans, "Large Deformation Simulations of Cyclic Displacement Instabilities in Thermal Barrier Systems," *in press*.

A.M. Karlsson, C. Levi, and A.G. Evans, "Effects of Morphology and Growth Strain on Displacement Instabilities During Cyclic Thermal Oxidation of Bond Coat Alloys," *in press*.

J.M. Ambrico, M.R. Begley and E.H. Jordan, "Stress and Shape Evolution of Irregularities in Oxide Films on Elastic-Plastic Substrates Due to Thermal Cycling and Film Growth," *Acta Materialia*, **49**[9], 1577-1588 (2001).

A.G. Evans, D.R. Murrin, J.W. Hutchinson, G.H. Meier and P.S. Pettit, "Mechanisms Controlling the Durability of Thermal Barrier Coatings," *Progress in Materials Science*, **46**[5], 505-553 (2001).

EXHIBIT H (cont'd)

M. Gell, K. Vaidyanathan, B. Barber, J. Cheng and E. Jordan, "Mechanism of Spallation in Platinum Aluminide/Electron Beam Physical Vapor-Deposited Thermal Barrier Coatings," *Metallurgical and Materials Transactions A*, **30**, 427-435 (1999).

K. Vaidyanathan, M. Gell, and E. Jordan, *Surface and Coatings Technology*, **133-134**, 28-34 (2000).

J.A. Ruud, A. Bartz, M.P. Borom and C.A. Johnson, *Journal of the American Ceramic Society*, **84**[7], 1545-1552 (2001).

V.K. Tolpygo and D.R. Clarke, *Acta Materialia*, **48**[13], 3283-3293 (2000).

Application No. 09/524,227
Technology Center 1762
Appeal Brief dated January 26, 2006

Related Proceedings Appendix

None.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

FEE TRANSMITTAL for FY 2004

Effective 10/01/2003, Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.23

TOTAL AMOUNT OF PAYMENT (\$) **500.00**

Complete if Known

Application Number: **09/524,227**
 Filing Date: **03/13/2000**
 First Named Inventor: **Spitsberg**
 Examiner Name: **Wesley Markham**
 Art. Unit: **1762**
 Attorney Docket No.: **13DV13004**

METHOD OF PAYMENT (check all that apply)

☐ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None

☒ Deposit Account

Deposit Account Number: **07-0565**
 Deposit Account Name: **General Electric Company**

The Director is authorized to: (check all that apply)

☒ Charge fee(s) indicated below ☒ Credit any overpayments

☒ Charge any additional fee(s) or any underpayment of fee(s)

☐ Charge fee(s) indicated below, except for the filing fee to the above identified deposit account.

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
1001 770	2001 385	Utility filing fee	
1002 340	2002 170	Design filing fee	
1003 630	2003 265	Plant filing fee	
1004 770	2004 385	Reissue filing fee	
1005 160	2005 80	Provisional filing fee	
SUBTOTAL (1) (\$)			

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

Total Claims: **20** * = **20** * **20** = **400**

Independent Claims: **1** * = **1** * **20** = **20**

Multiple Dependent: **19** * = **19** * **20** = **380**

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
1202 18	2202 9	Claims in excess of 20	
1201 85	2201 43	Independent claims in excess of 5	
1203 290	2203 145	Multiple dependent claim, if not paid	
1204 85	2204 43	** Reissue independent claims over original patent	
1205 18	2205 9	** Reissue claims in excess of 20 and over original patent	
SUBTOTAL (2) (\$)			

3. ADDITIONAL FEES

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
1051 130	2051 65	Surcharge - late filing fee or oath	
1052 50	2052 25	Surcharge - late provisional filing fee or cover sheet	
1053 130	2053 65	Non-English specification	
1812 2,520	1812 2,520	For filing a request for ex parte reexamination	
1804 920	1804 920	Requesting publication of SIR prior to Examiner action	
1805 1,840	1805 1,840	Requesting publication of SIR after Examiner action	
1251 110	2251 55	Extension for reply within first month	
1252 420	2252 210	Extension for reply within second month	
1253 950	2253 475	Extension for reply within third month	
1254 1,480	2254 740	Extension for reply within fourth month	
1255 2,010	2255 1,005	Extension for reply within fifth month	
1401 330	2401 165	Notice of Appeal	
1402 330	2402 165	Filing a brief in support of an appeal	
1403 280	2403 140	Request for oral hearing	
1451 1,510	1451 1,510	Petition to institute a public use proceeding	
1452 110	2452 55	Petition to revive - unavoidable	
1453 1,330	2453 665	Petition to revive - unintentional	
1501 1,330	2501 665	Utility issue fee (or reissue)	
1502 480	2502 240	Design issue fee	
1503 640	2503 320	Plant issue fee	
1450 130	1450 130	Petitions to the Commissioner	
1807 50	1807 50	Processing fee under 37 CFR 1.17(g)	
1808 180	1808 180	Submission of Information Disclosure Stmt.	
8021 40	8021 40	Recording each patent assignment per property (times number of properties)	
1802 770	2802 385	Filing a submission after final rejection (37 CFR 1.129(a))	
1810 770	2810 385	For each additional invention to be examined (37 CFR 1.129(b))	
1831 770	2831 385	Request for Continued Examination (RCE)	
1802 900	1802 900	Request for expedited examination of a design application	
SUBTOTAL (3) (\$)			500.00

Other fee (specify): _____

Reduced by Basic Filing Fee Paid: _____

SUBTOTAL (4) (\$)

SUBMITTED BY

Name (Print/Type): **William Scott Andes** Registration No.: **33,582** Telephone: **513/243-5965**

Signature: *[Signature]* Date: **January 26, 2006**

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